TITLE: Technology Trends for Future Business Jet Airframe

Technology trends for future Business Jet Airframe

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SUMMARY

Today's aerospace market is extremely tough ; the constant quest for reduced production cost in existing airframes may provide an opportunity for introducing new technologies through re-engineering of structural component.

This paper higlight the approach used at Dassault Aviation for the Falcon business jet family.

Withing the "technologies patchwork", choices and solutions are reviewed and discussed using examples.

1. GENERAL

Several new technologies are under study at Dassault-Aviation for their possible application, first to improve aircraft currently in production (Falcon 900B and 900EX , Falcon 2000 and Falcon 50EX) , and later on future models.

Introduction of new technology is not an objective by itself. Dassault approach (see fig 1) is that a new technology will be introduced only if it provides better value for money for the customer. Or the value side of the balance, safety is always top of the list and never to be compromised ; the other main components of value are dependability, performances (payload, range, speed)and comfort.

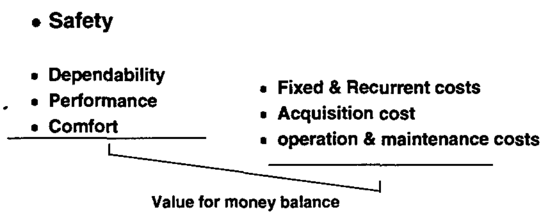

fig 1

On the cost side of the balance are acquisition cost , operation and maintenance costs.
To achieve such objective, two of the rules used are :
- One is to maximise the "family effect", i.e. to introduce new technology preferably on parts common to several makes of Falcons, in order to spread development cost on large production runs and also to save on recurring cost by being earlier down the learning curve.

- Another one is to asses and minimise all possible negative effects of a candidate new technology .

2. USE OF METALLIC SUBSTRUCTURE CONCEPT IN RELATION TO COMPOSITE DESIGNS

Organic composites such as carbon / epoxy have strong benefits compared to build up metallic structures:

- potential **weight saving** (up to 30%)

- **corrosion resistance** : carbon / epoxy parts are unaffected by corrosion . This can be a significant cost maintenance saving for example on a composite pressurised fuselage.

- **fatigue resistance** : composite are much stronger in fatigue than metallic materials.

But they have also negative aspects (to be assessed and minimised).

- Low performance for tridimensional loading (ie : fittings)

- **impact damage** susceptibility :

- **repairability** :

- **cost** of the raw material : to recover this initial cost, savings must be sought in "design for manufacturing" using , more integrated design diminishing part count and assembly man-hours , and dedicated new manufacturing techniques for example Resin Transfer Moulding of dry fibre preforms. In this respect use of new metallic substructures concepts are a way of designing innovatives structures with a good integration of metallic and composite component.

The philosophy is to design simple and robust structures trading one part of the possible weight saving in exchange of good impact damage resistance, easy manufacturing and repairability.

A good example of application of all theses concepts is the re-engineering for the Falcon horizontal tailplane, common to all types of Falcons (F 50, F 900, F 2000).

Existing design is a conventional riveted aluminium structure as shown figure 2 .

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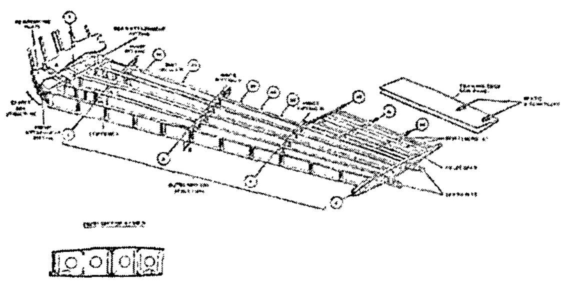
Fig 2



New design is shown figure 3.

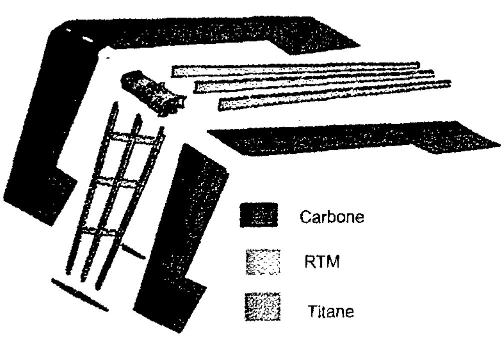


Fig 3

It comprises :

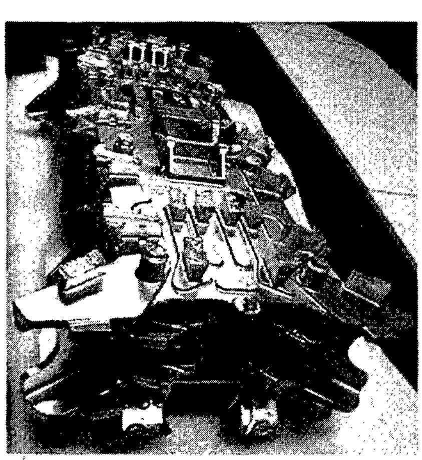
- carbon / epoxy skins, monolithic with some cocured hat stiffeners . The upper surface is a single panel from tip to tip.

- three spars by side , produced by Resin Transfer Molding and integrating some stiffeners and fittings.

- one structural central box consisting in one large titanium (6-4) casting integrating all the attachment fittings (see fig 4)

This part has been produced by investment casting process (see figure 5) .

Fig 4



From the 3D CATIA model, a pattern was first produced by stereolithography, (the use of strereolithography diminishes development time for prototype) a conventional wax model

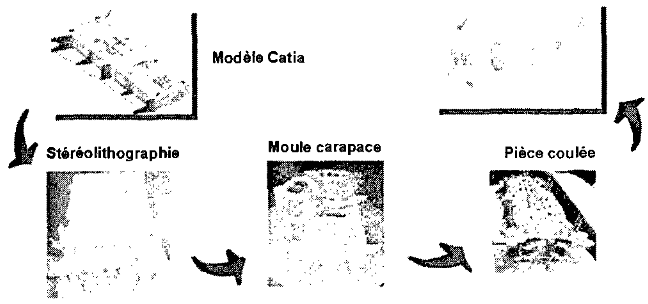


Fig 5

will be used for serie production ; the next step shows the ceramic shell mold ; post casting operations including hot isostatic pressing (HIP) represent a significant portion of cost of producing investment casting .

- leading edge remains the original aluminium one despite trials on low cost titanium SPFDB structure.

The reduction of part count and assemblies is quite obvious permitting significant savings in production cost.

The first horizontal tailplane (prototype) has been manufactured and is being tested with the objective of being certified within this year and being introduced in production line.

3. USE OF METALLIC UNITIZED STRUCTURES.

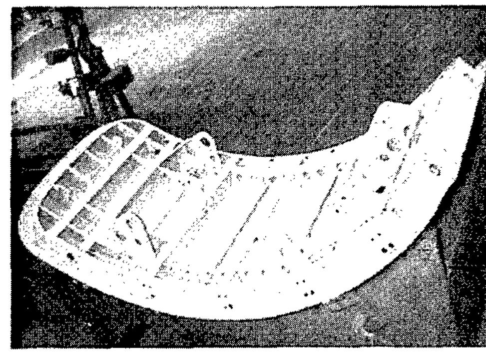
3.1 – Large size casting

For the designer, castings offers numerous advantages compared to conventional build-up structures:
- design freedom
- allows thin walled complex parts
- reduce parts and fasteners count

In contrast the use of large size casting result in difficulties dealing with dimensional tolerances.

Passenger door of Falcon 900 and Falcon 2000 is a conventional build up structure of aluminium sheet metal parts riveted together. (see fig 6)

Fig 6



The idea is there to simplify the structure by replacing all the build up internal structure by a single aluminium cast frame as shown in figure 7.produced by vacuum assisted sand casting.

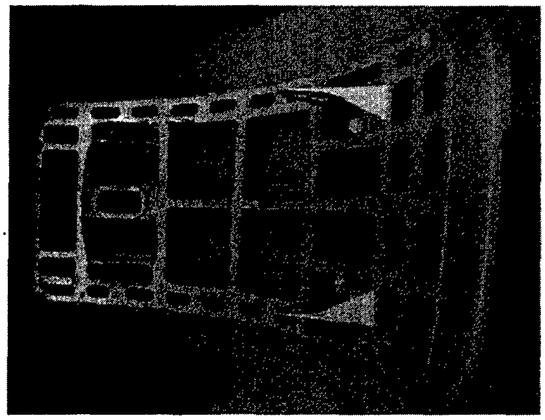


Fig 7

3.2 - High speed machining

The advent of very high speed machining with very high RPM spindle is providing two benefits : first the reduction in milling time, second the possibility to go down to very thin skins without cracking or buckling the part during machining.. That opens the way to cost efficient and weight efficient applications.

Two examples are in development :

- Airbrake (common to Falcons 50, 900, 2000) The initial design (aluminium skin bonded on aluminium honeycomb core) will be replaced by one single integrally stiffened part (see figure 8) with a drastic reduction in part count.

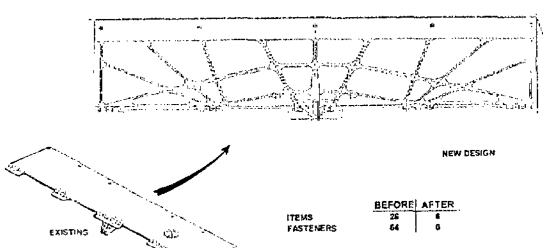
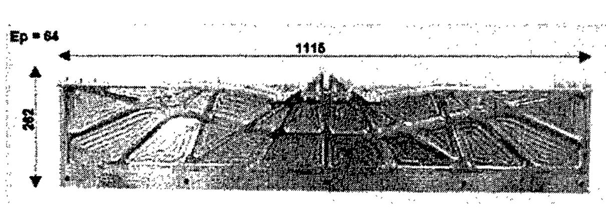


fig8



- Pitch control surfaces (common to Falcons 50, 900, 2000).

In this case, conventional aluminium build up structure will be replaced by a much simpler design using integrally stiffened panels.

4. CONCLUSION

Dassault-Aviation is keen to improve the competitiveness of its products, and for this purpose to introduce new technologies, quipping into mind than all aspects must be properly accounted for, including maintenance.

Paper 3

Question by Mr. Woithe

Have you examples of modification of aircraft parts resulting from fatigue problems in service.

Author's reply

Very few examples at Dassault

- replacement of some wing main spars on some MIRAGE III
- replacement of straker fitting on Mirage F1

Question by Mr. Lincoln

Are casting factors used for design? Has there been any experience with shell inclusions in Ti castings?

Author's reply

There is no casting factor for Titanium 6.4 castings. But in the case of the Falcon horizontal tailplane the titanium fitting has ample static margins because it is replacing aluminium fitting of the same dimensions. All the titanium cast parts are HIP treated and we have had no problem up to now, for example a titanium cast fitting used on the Mirage 2000.

Question by Frank Abdi

What is the margin of safety for fatigue of composite? is traditional I.S. safety considered?

Author's reply

Margin of I.S. is considered only for plane stress. In that case fatigue is never a problem due to the excellent strength of carbon epoxy composites.

Residual strength after impact is often the design device.